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The Development of Interactive Multimedia Virtual Laboratory to Enhance Students' Academic Achievement

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Abstract

The study aims to develop an interactive multimedia virtual laboratory that can increase student independence and learning achievement, and determine the effectiveness of its use. This research uses a development design (Research and Development) using the ADDIE model as a development method. The research subjects were X-grade science students at Bengkulu City High School. The data collection techniques used were assessment sheets and student test results, and data analysis using the average (mean), paired test, and independent sample t-test. Expert validation and student response to the product in this study were carried out using a Likert scale. The results show that the developed interactive virtual laboratory multimedia is suitable for improving students' learning achievement in chemistry with the topic of electrical conductivity, based on limited trials and large-scale tests with X-grade students in Bengkulu City high schools. Additionally, the interactive virtual laboratory multimedia was published in the form of a PowerPoint show.

A. Introduction

Education plays a vital role in helping students develop their potential, and teachers play a crucial role in assisting students in achieving this goal. Through proper education, students can develop the skills and knowledge needed to achieve success in life. Therefore, teachers need to have the necessary skills and knowledge to help students reach their potential in education. Quality teachers have high ability and competence in providing instruction to students, thus enabling them to reach their best potential. One characteristic of quality teachers is giving attention and paying attention to the development of their students (Sutirna, 2013). In the era of the Fourth Industrial Revolution, the role of quality teachers is vital as it extends beyond traditional teaching. They are responsible for nurturing and facilitating the skills and knowledge that students require in the rapidly evolving workplace. Quality teachers must possess the ability to effectively utilize the latest technology in the learning process, enabling students to become adept at utilizing the technological tools demanded in the workplace. Moreover, they should foster creativity and innovation in learning, empowering students to develop critical thinking and problem-solving skills essential in the Fourth Industrial Revolution era. Therefore, the role of quality teachers is paramount in equipping students with the necessary competencies to confront the challenges of the modern workforce in the Fourth Industrial Revolution era.

The era of the Fourth Industrial Revolution brings significant changes to education. In the era of the Fourth Industrial Revolution, there are impacts such as the availability of information that can be accessed and found anywhere and anytime, faster computing, automation that can replace routine tasks, and the ability to communicate anywhere and anytime (Wijaya at al., 2016). The advancement of technology and digitization has influenced the way students learn and changed the demands of the job market. The use of technology in the learning process has become increasingly important in the current digital era. Technology can help improve the effectiveness, efficiency, and quality of learning. Based on interviews conducted with

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three schools in Bengkulu city, namely SMAN 4, SMAN 6, and SMAN 7, it was found that the topic of electric conductivity is difficult for students to understand because teachers have difficulty explaining ionization reactions during experiments. As a result, the quality of learning is disrupted and students cannot achieve optimal learning outcomes. Virtual laboratories are one of the technologies used in learning in the era of the 4th industrial revolution. Virtual laboratories allow students to conduct experiments and experiments in a safe and controlled simulation environment without requiring the use of expensive chemicals or equipment. In addition, virtual laboratories also allow students to learn independently and explore difficult concepts in science and technology learning. The use of virtual laboratory technology is expected to improve student's skills and knowledge in the field of science and technology and prepare them to face the challenges in the increasingly complex and diverse era of the 4th industrial revolution.

The virtual chemistry laboratory is a computer program that depicts and simulates chemical experiments through interactive graphical displays (Meyer & Hendrian, 2020). This virtual laboratory enables students to conduct chemistry experiments without directly using hazardous or expensive chemicals in a physical laboratory. In the virtual chemistry laboratory, students can learn and observe chemical phenomena, such as chemical reactions, phase changes, chemical properties of a substance, and others, through realistic three-dimensional models. Additionally, the virtual chemistry laboratory also allows students to simulate and predict the results of different chemical experiments digitally. The virtual chemistry laboratory can be used as an effective and efficient learning medium to teach complex chemistry concepts in a more interestingly and interactively. The virtual laboratory is used to gain conceptual understanding and develop skills in the scientific process (Peffer at al., 2015). Virtual laboratories have several advantages that make them an attractive choice for learning, especially in the era of Industry 4.0 revolution. Firstly, virtual laboratories can provide a learning experience that is almost similar to the experience gained in physical laboratories, without the need for high costs and even can be done remotely. Secondly, the use of virtual laboratories can help students understand difficult or abstract concepts in a more interactive and enjoyable. Thirdly, virtual laboratories can also accelerate the learning process, as there is no need to wait for turns or prepare tools and materials. Fourthly, the use of virtual laboratories can enhance students' creativity and allow them to conduct more complex and complicated experiments or research. Therefore, virtual laboratories can be an effective and efficient alternative to improving the quality of learning in the era of Industry 4.0.

Based on the problem explained earlier, the development of interactive multimedia learning media in the form of virtual laboratory is needed in the 10^{th}-grade science class for the subject of chemistry which can display the depiction of ionization reactions that can improve students' understanding.

B. Research Methods

The research methodology refers to a systematic approach employed to gather data with a defined objective and purpose, ensuring the acquisition of valuable insights and advantages (Sugiyono, 2018). The method applied in this research is descriptive method. Descriptive method is used to obtain information about independent variables, whether it is one or more variables (unrelated variables) without making comparisons or finding relationships between variables (Sugiyono, 2015). The research conducted for the creation of interactive virtual laboratory multimedia adopts the research and development approach using the ADDIE development model. The objective of this development research is to elucidate the product's characteristics through feasibility testing to enhance learning achievement. The research primarily centers around the Chemistry subject taught to class X MIPA students at SMAN 4 and SMAN 7 in the city of Bengkulu, specifically focusing on the topic of electrical conductivity. The research encompasses five key stages: 1) Analysis, 2) Design, 3) Development, 4) Implementation, and 5) Evaluation (Pribadi, 2014). The five stages in the ADDIE model should be carried out systematically. The overall instructional system design model ADDIE can be seen in Figure 1 (Tegeh at al., 2014).

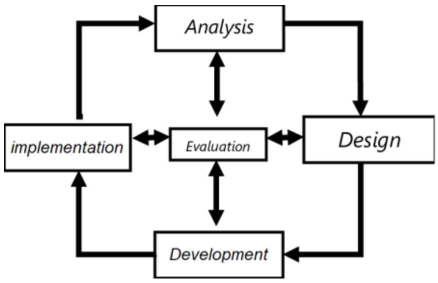

Figure 1. The concept of ADDIE Model Development

The preliminary activities in this study involved a needs analysis in three schools in Bengkulu city, namely SMAN 4, SMAN 6, and SMAN 7. In the initial stage, interviews were conducted with grade X chemistry teachers in the three schools, and questionnaires were distributed to 105 students from the three schools. This initial activity aimed to obtain information regarding curriculum analysis, materials, and student analysis. The following are the results of the initial study obtained from interviews and questionnaires. The needs analysis stage was carried out on January 16-17, 2023.

The product validity testing stage was carried out by three experts, including two lecturers from FKIP Bengkulu University and a chemistry teacher who is a friend of Bengkulu province's technology ambassador in 2022. Product validity was assessed based on three aspects, namely material, media, and language. This product validity testing was carried out on February 20-24, 2023.

The limited trial stage was conducted at SMA Negeri 4 Bengkulu City for class X students. There were 2 classes involved with a total of 20 students in each class. This limited trial aims to test the virtual laboratory interactive multimedia to students in the class. The results of this limited trial will be input from students who will be evaluated and used to improve and revise the product. The limited trial was conducted on March 3-10, 2023.

After revisions were made and considered to meet the standards set, a broad-scale trial stage was carried out using a larger sample. At this stage, virtual laboratory interactive multimedia products are applied in chemistry learning, especially in electrical conductivity material. The purpose of this broad-scale trial is to evaluate the effectiveness of the product in increasing students' independence and learning achievement. The research design used involved pretest, post-test, and observation. The broad-scale trial was conducted in 1 class of X grade students at SMA Negeri 4 Bengkulu City and 1 class of X grade students at SMA Negeri 7 Bengkulu City. The implementation of the broad-scale trial was carried out on March 13-27, 2023.

C. Result and Discussion

At this stage of the analysis, the following were found: (1) Sometimes students feel bored with the media used by the teacher; (2) Teachers have not used a variety of media; (3) Teachers and students need interesting media to make it easier to understand chemistry lessons during the learning process; (4) The electrical conductivity practicum cannot explain the ionization reaction that occurs; (5) Teachers need to use virtual laboratory interactive multimedia in electrical conductivity material as an alternative solution to improve learning outcomes and motivation in the chemistry learning process.

In the design stage, the goal is to outline the overall multimedia content. The design process involves selecting media, formats, compiling comparison tests, and designing the initial product. These steps lead to the creation of an initial design for the laboratory virtual interactive multimedia product.

From the initial investigation, the researcher designed an interactive multimedia in the form of a virtual laboratory that can assist students in conducting experiments and developing their knowledge, attitudes, and skills. After the development phase, the design was tested for its feasibility by experts and then piloted with X MIPA students. As demonstrated in Sudana's (2022) study on the development of an integrated interactive virtual laboratory with the MOODLE LMS to improve physics learning outcomes for grade XI high school students (Sudana et al., 2022).

The produced interactive virtual laboratory multimedia consists of several parts: home page, main menu page for learning, instruction on how to use the learning menu, competency page, material page, evaluation page, reference page, developer information page, instruction on how to use the practical menu, practical page, and practical animation page. The following is the result of the development of interactive virtual laboratory multimedia.

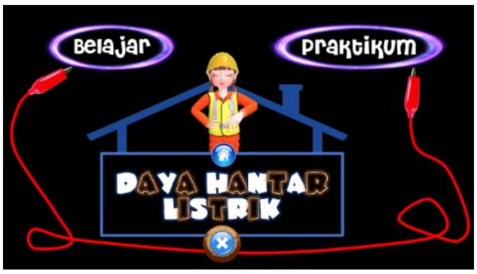

Figure 2. Multimedia Start Page

The produced interactive virtual laboratory multimedia consists of several parts: home page, main menu page for learning, instruction on how to use the learning menu, competency page, material page, evaluation page, reference page, developer information page, instruction on how to use the practical menu, practical page, and practical animation page. The following is the result of the development of the interactive virtual laboratory multimedia.

Figure 3. Main menu page for learning

Figure 3 shows the main page of the interactive multimedia virtual laboratory that serves as a learning tool. This page displays several important elements designed to provide an interactive and informative user experience, such as the logo of Bengkulu University, the name of the product, the title of the material being studied, and a navigation menu that can assist users in obtaining information from various parts of the product.

Figure 4. Menu Learning Instruction Page

These interactive multimedia is equipped with instruction pages on learning content and practicum content. The instructions page for learning content contains information on how to use and explore virtual laboratory interactive multimedia. The purpose of the instructions page is to provide users with clear and easy-to-understand information on how to use virtual laboratory interactive multimedia. Some of the elements contained in the instructions page on interactive multimedia include: Product usage and navigation instructions. In this section there is also an explanation of the icons, menus, and buttons used in the product. The instructions page on the learning content can be seen in Figure 4.

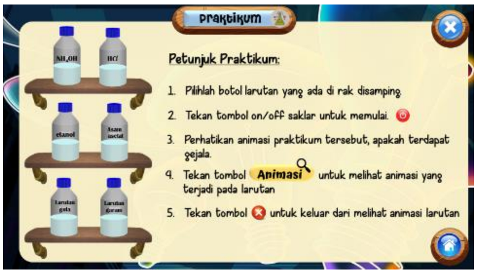

Figure 5. Practicum Menu Instruction Page

Instructions for using the practicum menu in interactive multimedia contain information on how to use and explore the practicum in the virtual laboratory interactive multimedia. The purpose of the practicum menu page as a guide to provide information for users that is clear and easy to understand about how to use the virtual laboratory interactive multimedia practicum. Some elements contained in the practicum menu page on interactive multimedia include instructions for using the practicum and navigation contained in the bottle on the shelf on the left. In this section, there is also an explanation of the icons, menus, and buttons used in this product. The instructions for this practicum menu can be seen in Figure 5.

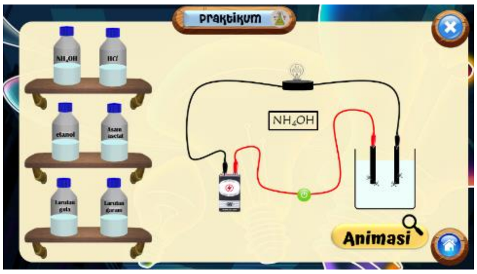

Figure 6. Practicum Page

The virtual laboratory interactive multimedia practicum page can be seen in Figure 6. Here, there are practicum animations designed to match the situation that occurs in the real world. In addition, this practicum page is equipped with navigation buttons that are connected to other practicum sections. The practicum page in this interactive multimedia aims to provide an interactive and informative learning experience, and allows students to do the practicum independently.

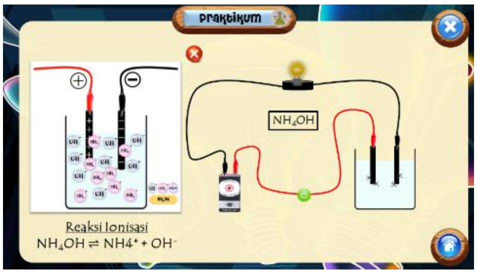

Figure 7. Practicum Animation Page

Virtual laboratory interactive multimedia is equipped with an animation page to overcome problems in learning in the form of depicting ionization reactions that occur during practicum. This practicum animation page contains animated explanations that occur in practicum. This page contains animations and navigation buttons that are connected to return to the practicum site. The practicum animation page on this multimedia is designed to provide microscopic learning explanations. The practicum animation page can be seen in Figure 7.

These virtual laboratory interactive multimedia is a practical learning resource to be used in learning because it meets the criteria of practicality with ease of use as an appropriate learning resource and suitable for use by students. There are clear work instructions in the virtual laboratory interactive multimedia so that students are not confused when doing learning activities. Virtual laboratory interactive multimedia can help students understand the subject matter and develop knowledge, attitudes, and skills. The selection of learning media for a teacher must pay attention to applicable principles. One of them is choosing media that can really be used or applied in learning. This will help improve the quality of learning (Rusman, 2018). The reason teachers choose to use learning media is also active learning, where students can play an active role both physically, mentally and emotionally (Susilana & Riyana, 2017).

The results of the virtual laboratory interactive multimedia development research show that this tool can be used in learning to improve student learning achievement. Based on the results of validation by experts, the overall average value is 3.95 with the category "very feasible to use" in learning to improve student achievement. This can be seen in table 1 below.

Table 1. Final Assessment of Interactive Multimedia Products

Validator	Average Rating Score	Value	Category
Expert Lecturer I	4	A	Very Feasible
Expert Lecturer II	3,86	A	Very Feasible
Chemistry Teacher	4	A	Very Feasible
Final Product Assessment	3,95	A	Very Feasible

Attention to the relevance of basic competencies and learning indicators is one of the important factors that must be considered in evaluating the feasibility of media. In addition, the product has been well validated because during the design process, it is based on the guidelines in the interactive learning multimedia book

(Dwiningsih et al., 2018). In his book, Surjono explains that interactive multimedia in learning must fulfill three aspects of criteria, namely content, instruction, and display (Surjono, 2017). The average student response to the interactive multimedia virtual laboratory as a whole reached 4.47 with a grade of A and the category "very good". Based on these results, it can be concluded that the virtual laboratory interactive multimedia is very effective to be used in learning chemistry with electrical conductivity material. Student responses to this tool are illustrated in Figure 8 below.

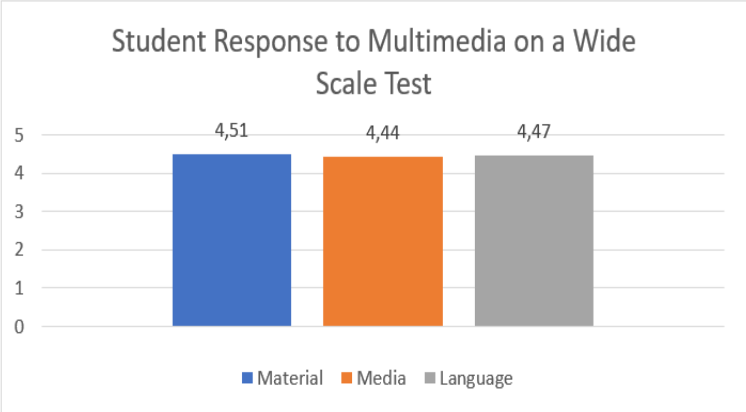

Figure 8. Student Response to Multimedia on a Wide Scale Test

A study was conducted to assess the effectiveness of virtual laboratory interactive multimedia in enhancing student learning achievement. The research consisted of a limited trial and a broad-scale test. In the limited trial, 20 students in the experimental class utilized virtual laboratory interactive multimedia, while 20 students in the control class followed conventional learning methods. The findings revealed a significant distinction between the two groups, with a Sig (2-tailed) value of 0.001. The average post-test scores of the experimental class surpassed those of the control class, indicating that the virtual laboratory interactive multimedia was more effective in improving learning achievement. Similarly, in the broad-scale test, 30 students in the experimental class and 30 students in the control class exhibited noteworthy differences, with a Sig (2-tailed) value of 0.005. The average post-test scores of the experimental class remained higher than those of the control class, indicating that the virtual laboratory interactive multimedia continued to be effective in enhancing learning achievement. These findings align with Purwandari's research (2019), which suggests that the utilization of virtual laboratories is effective in increasing students' motivation and cognitive learning outcomes and can be easily implemented (Purwandari, 2019).

Based on the outcomes of both the limited and wide-scale trials, it is evident that the use of virtual laboratory interactive multimedia can enhance student learning achievement. In the limited trial, a group of 20 students from X MIPA 1 SMAN 4 Bengkulu City utilized virtual laboratory interactive multimedia, while another group of 20 students from X MIPA 2 SMAN 4 Bengkulu City followed conventional learning methods. The results indicated a significant disparity in the average learning outcomes between the two student groups. Similarly, during the broad-scale test, 30 students from X MIPA 5 SMAN 4 were assigned as the experimental class, whereas 30 students from X MIPA 3 SMAN 7 served as the control class. The findings of this test also demonstrated that the use of virtual laboratory interactive multimedia was more effective in improving learning outcomes compared to conventional learning. Consequently, it can be concluded that virtual laboratory interactive multimedia is superior to conventional learning in enhancing student learning achievement. These findings align with Sudana's (2022) research on the development of interactive virtual laboratories integrated with MOODLE LMS in high school physics learning, which revealed the effectiveness of virtual laboratories in improving student learning outcomes in class XI SMA. This research is consistent with a previous study conducted by Clark et al. (2014) in a journal that evaluated students facing challenges in understanding the concept of thermodynamics, employing a series of questions and observations before and during learning (Clark at al., 2014).

In this study, stage evaluation was conducted using formative evaluation. Formative evaluation in the ADDIE development model serves to monitor progress in each stage of development and ensure that the developed product is in accordance with the objectives and needs of students. By conducting formative evaluation, improvements can be made quickly and effectively at each stage of development, so that the final product can achieve the predetermined goals.

D. Conclusion

Based on the results of the research that has been conducted and the discussion described in the previous chapter, it can be concluded as follows: (1) Virtual laboratory interactive multimedia on electrical conductivity can visually show abstract concepts in lessons and does not require special installation when used. This is because the multimedia is made as a Microsoft PowerPoint presentation that can be used directly on devices that already have the application. (2) In this study, an interactive multimedia virtual laboratory for chemistry with the theme of electrical conductivity was developed. The final product has been assessed by experts and received a score of 3.95 with the criteria that it is very suitable for use in teaching to improve student learning abilities. Positive responses from students with a score of 4.52 indicate that these virtual laboratory interactive multimedia is very feasible to use in learning because it can improve student learning achievement. (3) The results of this study indicate that interactive multimedia is more effective in improving student learning outcomes compared to conventional learning methods.

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